

A complex adaptive systems approach to the study of common multifactorial diseases. C.F. SING, M.R. NELSON, J.H. MOORE and S.L. KARDIA, Human Genetics and Epidemiology, U. Michigan, Ann Arbor, MI 48109-0618

As with all complex adaptive systems, health is an emergent property of non-linear relationships among many interacting agents that are dynamic in time and space. An individual's phenotype at a particular age is predicted by the norm of reaction that is determined by interactions of her, or his, genotype with all possible environmental exposures over the life cycle. The history of each individual is represented by one of the many possible trajectories of phenotypes. Identifying which combinations of genotypes and environmental histories are predictors of a common multifactorial disease in particular subsets of individuals, families or populations is the most difficult research challenge facing human geneticists today.

We are incorporating a complex adaptive systems approach in our studies by taking into consideration dynamic features of phenotypes and multilocus genotypes which underlie the continuous measures of health. For example, dynamic features of ambulatory blood pressure measurements reflect physiological and environmental processes that regulate blood pressure (BP). Our analyses of linear and nonlinear dynamic BP traits implicate the role of a greater number of candidate genes from the renin-angiotensin system than the analysis of static traits. We are also researching methods for identifying the combinations of loci that contribute to interindividual variation in health and asking which genotypic combinations contribute to the mix of invariant features, context dependent features and chance processes that influence risk of disease. We have developed a combinatorial partitioning method that identifies functional genotypes at multiple genes and multiple loci simultaneously. Application of this method to measures of lipid metabolism and 18 loci from six gene regions reveals a great deal of nonadditivity between loci that would not be identified if considered separately. The relationship between slowly evolving DNA information and dynamic biochemical and physiological systems and the combinations of genotypes and environments that define the subsets of individuals at risk to a common disease will be central issues in functional genomic studies of the 21st century.

The cholera years in Rochester, New York. J.E. SIRIANNI, Department of Anthropology, SUNY at Buffalo, NY 14261.

Cholera was the major epidemic disease of the nineteenth century. It first appeared in the United States in 1832, flourished in the great cities and was spread through out the country with the unprecedented development of trade and transportation. One of the major trade and transportation routes of New York State passed through Rochester, NY connecting it to Canada to the west and New York City to the east. The railroad and Erie Canal not only brought trade goods and immigrants to Rochester, they also facilitated the spread of disease.

For most of the last century, all deaths in the Rochester

area were recorded by the Mt. Hope Cemetery. Today over 10,000 burial records chronicle the cause of death mid-nineteenth century Rochester. Contained in these records are the following: date of death, name of deceased, cause of death, address, and burial location within the cemetery. These data provide an opportunity to describe the incidence, pattern and spread of cholera in the city of Rochester in 1849, 1852 and 1854.

In 1847 and 1848, 11 out of 1,326 deaths reported for those years were attributed to cholera. However during 1849, cholera was recorded as the cause of death for 19.5% of those who died that year. For 1850 and 1851, the numbers of death due to cholera dropped to less than 1%. But, rose again in 1852 when 41.1% of the 757 deaths recorded for that year were attributed to cholera. During the next year, the disease was quiescent with only 13 cases reported. The incidence climbed again in 1854 to 15% of the reported deaths.

During each of the cholera years, the pattern of death was similar. Children were relatively safe with regard to cholera while middle aged adults were at risk. Also in each of the three epidemics, the disease took its heaviest toll during the summer months, July and August, and was most prevalent in the older and more densely populated, downtown section of the city spreading along the streets flanking the Genesee River, e.g. State, Mill, St. Paul, and Clinton Streets.

Geometric motion analysis. D.E. SLICE, Department of Ecology and Evolution, SUNY at Stony Brook, NY 11794.

Geometric morphometrics provides methods to study the shapes of bones, brain structures, insect wings, and any number of other more-or-less rigid body parts. Here, I propose a method by which the geometric methods can be extended to the study of dynamic shape changes necessary for the analysis of motion. Such extensions would make the robust and unique analytical and visualization methods of geometric morphometrics available to the field of motion analysis and allow for the development of new methods specific to that field.

In outline, the proposed method is as follows:

1. Identify landmarks that sufficiently capture the shape changes associated with the motion, and digitize the coordinates of this set of points throughout the motion.
2. Consider each configuration of points a shape and superimpose them using the standard methods of geometric morphometrics.
3. Treat the ordered set of superimposed shapes as a trajectory through shape space — cyclical motions will repeatedly trace the same path. Parameterize this trajectory for each realization of a motion using Elliptical Fourier Analysis (EFA).
4. Apply standard statistical analyses to the EFA parameters.
5. Use the EFA results to estimate points of interest (e.g. mean trajectories) in shape space.
6. Use the methods of geometric morphometrics to visualize these shapes.

Tests of steps 1-4 using simulated motions of 2D, triangular configurations show this method can effectively identify relatively subtle variations in motion. Extensions to

more complicated shapes, 3D data, and the addition of steps 5 and 6 are straightforward and currently under development.

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Remembering Malthus: Making the case for a significant reduction in global human numbers. J. K. SMAIL, Department of Anthropology/Sociology, Kenyon College, Gambier, OH, 43022

In a recent "roundtable exchange" (*Politics and the Life Sciences* 16(2):1997), I argued that a significant decrease in global human numbers over the next two or more centuries appears to be a necessary (if not inevitable) response to an exponential population growth that shows numerous signs of having *already* exceeded the Earth's long-term optimal carrying capacity.

This claim is based on the growing "disparity" between two seemingly irreconcilable trends: (1) moderate-to-conservative projections that human population size will almost certainly reach 9 to 10 billion by mid/late 21st century; and (2) steadily increasing empirical evidence that the Earth's long-term and sustainable carrying capacity, at an adequate-to-comfortable standard of living, may not be much greater than 2 to 3 billion.

If this is indeed the case, it is clearly in our species' best interest to undertake as soon as possible the very difficult and very lengthy process, both scientific and sociopolitical, of slowing, stopping and then *reversing* our currently upward demographic trajectory, particularly if it is necessary to contemplate a global population reduction of 50% or more.

This paper further reflects on: (1) the quantitative underpinnings and scientific validity of this admittedly controversial proposal; (2) the critical need for more effective methods of measuring local, regional and global carrying capacities, with particular focus on establishing population *optimums* (rather than maximums); (3) the important contribution to be made by the developed world in confronting the above-mentioned demographic "bottleneck"; (4) the political wisdom, as well as the ecological and demographic necessity, of focusing on population stabilization and reduction *now*, half a century (or more) before it has any chance of becoming an established reality; and (5) the need for biological anthropologists, as students of ongoing human evolution, to pay greater professional and pedagogical attention to what may well be the greatest crisis our species has yet encountered.

Statistical issues with the use of ratios and residuals as measures of sexual size dimorphism in comparative studies. RICHARD J. SMITH, Dept. of Anthropology, Washington University, St. Louis, MO 63130

In comparative studies of sexual size dimorphism (SSD), the methods used to quantify dimorphism are

controversial. SSD is commonly expressed as a ratio between species mean values of males and females, such as M/F or $(M-F)/[(M+F)/2]$, but a number of investigators (e.g., Ranta *et al.*, *Oikos* 70: 313-321, 1994; Abouheif and Fairbairn, *Am. Nat.* 149: 540-562, 1997) have suggested that ratios should not be used, mainly because their distributions usually violate the assumptions of parametric statistical tests, or because they lead to spurious relationships that invalidate the interpretation and statistical significance of regressions and correlations.

Twenty-five data sets were selected from the literature and used to duplicate a variety of statistical procedures commonly employed in studies of SSD. All analyses were repeated with five different ratios and with methods that avoid the calculation of any ratios. These data and a review of the statistical properties of ratios and residuals indicate that: (1) most of the ratios used in the SSD literature are unnecessary, and several commonly used ratios are statistically inferior to others. Only two ratios are needed, one on a logarithmic scale and one on a linear scale, (2) there is no problem with spurious correlation or non-normality when ratios are used in the statistical procedures commonly employed in studies of SSD, and (3) residuals cannot replace ratios for the evaluation of many questions regarding the pattern of SSD among species. On the contrary, it often may be essential to use ratios to understand the pattern of SSD in comparative data sets.

These conclusions hold for studies that use statistical methods that treat species as independent data points and for those that use methods to correct for phylogenetic relationships, such as independent contrasts and autocorrelation.

Position of the vomeronasal organ in adult humans and mouse lemurs. T.D. SMITH, N.M. CERQUA, H.P. HOFFMAN, T.A. BUTTERY, A.M. BURROWS, School of Physical Therapy, Slippery Rock Univ., Slippery Rock, PA, 16057, M.P. MOONEY, M.I. SIEGEL, Dept. Anthropology, Univ. of Pittsburgh, Pittsburgh, PA, 15260.

Despite a renewed interest in the human vomeronasal organ (VNO), the spatial relationship of the adult human VNO to other nasal cavity elements is only partially known. In addition, there have been no scaled comparisons of the human VNO to those of primates known to have well developed VNOs.

Histologically sectioned nasal septa from 15 adult human cadavers and 3 adult mouse lemur cadavers (*Microcebus murinus*) were examined by light microscopy and retrospectively compared to scaled photographic slides of the whole septa. Percentages were calculated, including VNPC (VNO length/ paraseptal cartilage length) and VNPL (VNO length/ palatal length).

Human VNOs varied in anteroposterior and superoinferior position relative to the anterior nasal spine and nasal cavity floor. In absence of a visible duct, no reliable surface markings were noted except that human VNOs were frequently found superior to swellings associated

with the paraseptal (vomeronasal) and/ or septal cartilages. The paraseptal cartilages of humans extended farther posteriorly than the VNOs; the opposite was noted in mouse lemurs. VNPC was approximately 39% in humans and 99% in mouse lemurs; VNPL was approximately 12% in humans and 37% in mouse lemurs. Such findings suggest that the human VNO is positionally variable, which may have contributed to conflicting findings regarding presence *versus* absence. Results also indicate that the human VNO is proportionately smaller than in the mouse lemur, in agreement with studies which have shown that a central connection site (accessory olfactory bulb) of the VNO is relatively large in strepsirrhine primates and may be absent in humans. Further comparisons are needed, with a renewed effort to search for VNOs in Old World primates.

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Interspecific variation in body composition and its influence on metabolic variation in primates and other mammals. J.J. SNODGRASS. University of Florida, Gainesville, FL 32611, W.R. LEONARD and M.L. ROBERTSON. Northwestern University, Evanston, IL 60208.

Bioenergetics, the use and transfer of energy, can be used to provide important information on the ecology and evolution of hominids and other mammals. Previous research on primates and other mammals has shown similar scaling relationships between body mass and basal metabolic rates (BMR). However, marked deviations from the so-called "Kleiber" scaling relationship between mass and BMR are evident in many species. It seems likely that interspecific variation in body composition may directly contribute to such metabolic variation given that tissues vary in their metabolic demands. Yet, these differences in body composition (e.g., relative amounts of muscle, bone, skin, fat, brain, and viscera) have not been widely explored in energetic studies. Thus, the purpose of this study is to examine the influence of variation in body composition on metabolic rates of diverse mammalian species.

Body composition is highly variable in mammals and is strongly correlated with locomotor patterns. Muscle mass, for example, varies from 23-53% of body mass in mammals. Arboreal folivores (e.g., *Bradypus* and *Alouatta*) tend to cluster at the low end of the range, and also tend to have low overall metabolic requirements. Terrestrial mammals (e.g., *Canis* and *Macaca*), on the other hand, have higher muscularity indices along with greater energy demands. Our results suggest ecological differences in locomotor and dietary patterns across mammalian species influence variation in body composition. In turn, these body composition differences shape interspecific variation in energy demands.

Body weight trajectories in primate evolution: The evidence from nails and claws. C. SOLIGO and A.E. MÜLLER, Anthropologisches Institut und Museum, Universität Zürich-Irchel, 8057 Zürich, Switzerland.

Many authors believe that the last common ancestor of the living primates had nails rather than functional claws. It is unclear though, why functional claws should have been reduced to nails in the lineage leading to this ancestor. It has been suggested that claws are in some way disadvantageous when moving along small terminal branches, and would therefore be selected against, or that enlarged apical pads are better adapted for this kind of environment, resulting in claws being reduced as a by-product of widening the terminal digital phalanges. Since some Callitrichidae forage successfully among small terminal branches despite their functional claws, neither of these two reasons is in itself sufficient to explain the loss of functional claws.

We present a new hypothesis in which a significant increase in body size in the lineage leading to the last common ancestor of the living primates was the cause of the reduction of functional claws. The increased body weight limited, for physiological reasons, the efficiency of claws for arboreal locomotion to the point where they were lost. Comparison with the body weight distribution of clawed arboreal mammals suggests an initial body weight of at least 1 kg for the last common ancestor of the living primates.

In support of this hypothesis we present evidence from the histological structure of primate nails and claws. Primate nails and claws may consist of either one or two distinct horny layers, depending on whether in addition to the basal germinative matrix, which gives rise to a superficial layer, a terminal germinative matrix is also present, generating a deep layer. Reconstruction of the evolutionary pathways of these character-states across a consensus phylogeny of primates shows that the presence of two distinct layers is the likely ancestral state. In contrast, all of the smallest nail-bearing species included in our current sample (*Tarsius*, *Microcebus*, *Nycticebus*, *Galago demidovii* and *G. senegalensis*) are derived in that they retain only one of the ancestral layers. The link between secondary loss of the deep horny layer and small body-size is evidence that within the living primates small size is a secondary feature. This implies that all of the small bodied primates are the result of phyletic dwarfism.

Inferences for childhood nutrition from laser ablation inductively coupled plasma-mass spectrometry (LA-ICP-MS) of dental hard tissues. R.J. SONG, Univ. of Mass. Amherst, MA 01003, and A.H. GOODMAN, Hampshire College, Amherst, MA 01002.

To date, the analysis of hard tissue composition to infer childhood nutrition has been clouded by challenges in pinpointing precise periods of early development. Laser ablation inductively coupled plasma-mass spectrometry (LA-ICP-MS) provides semi-quantitative determinations of elemental composition and isotope ratios which may

overcome this problem. It offers several advantages: rapid, multielement analyses, low detection limits, minimal sample preparation, and importantly, for paleonutritional studies of archaeological specimens, high spatial resolution and minimal sample destruction.

While it has been effective in tracing environmental pollution, habitat origins, and the extent of diagenesis in hard tissues, here, we suggest that LA-ICP-MS of dental enamel can also provide inferences for childhood nutrition. This study utilizes the unique abilities of LA-ICP-MS to spatially trace elemental composition in human teeth, which, due to their kymographic nature, provide an indelible databank of events during early development.

To assess the validity of hard tissue elemental composition as a reflection of nutritional status at the time of their formation, the teeth of contemporary Mexican and Egyptian participants of the Nutrition Collaborative Research Support Program (CRSP) are employed. Detailed documentation of nutrient intake, illness episodes and growth during early life provides invaluable individual biographies which can be compared to enamel elemental profiles (eg. Ba, Fe, Sr, Zn) specific to periods such as fetal development and weaning.

Preliminary results suggest that zinc composition of deciduous teeth correlate with maternal protein intake rather than total zinc intake. In this way, application of LA-ICP-MS to paleonutritional studies should shed light on the complex relationship between dietary intake, element bioavailability and consequent hard tissue composition.

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Neck proportions in modern humans and Neanderthals. F. SPOOR and W. WOOD, University College London, WC1E 6JJ, U.K.

Neck proportions influence the frequency spectrum of head movements made during locomotion. They are therefore of interest to studies investigating the relationship between the semicircular canal system, which records angular head movements, and different types of locomotor behavior. Functionally relevant morphology of the semicircular canals in Neanderthals is closer to that in the great apes and australopithecines than to that seen in both modern humans and *Homo erectus*. This demonstrates that any link between hominid canal morphology and locomotion exceeds a simple association with the broad categories of facultative versus habitual bipedalism.

An aspect that deserves further investigation in this context, is whether the neck proportions in Neanderthals differ from those in modern humans, in a way that could, at least in part, explain their dissimilar semicircular canal morphologies through the association with distinct frequency patterns of head movement. In particular, the question can be asked whether Neanderthals had a bulkier neck, a type of morphology commonly associated with the great apes.

To obtain the comparative framework for analyzing

neck proportions in modern humans and Neanderthals a morphometric study was made of this region in a wide range of extant primates. Measurements of the vertebral column, the clavicles, the sternum and the nuchal area were taken from a total of 60 skeletons, representing 37 species.

Primates are found to be remarkably similar in their neck proportions, and the extant hominoids, including humans, only stand out by a greater shoulder width. The bulkier neck of the great apes compared with humans appears solely the consequence of the more superior position of their shoulder girdle, and not because of a shorter cervical spine, an expanded nuchal area or broader shoulders. Based on these results the available evidence for Neanderthal specimens from, among others, Kebara, Shanidar and La Ferrassie can now be evaluated, including the initial indication that the Kebara 2 cervical spine is shorter than in modern humans, when considered relative to either total spine length or the estimated width of the neck.

Forensic Anthropology: Education through Internship. M.K. SPRADLEY, University of Arkansas, Fayetteville.

Forensic anthropology is primarily applied within the medico-legal context. Forensic anthropologists are appearing in court answering questions pertaining to trauma rather than individual identification (Reichs, 1995). There are several universities that specialize in training forensic anthropologists. Others offer training in osteology and skeletal biology, without specialized training in the medico-legal background (Galloway, 1997). It is imperative that MA and Ph.D. students who wish to be forensic anthropologists know the medico-legal system. Since Medical Examiners are sending most cases to the forensic anthropologists, why not go straight to the source of understanding the medico-legal process?

In response to these training problems in forensic anthropology, the Department of Anthropology at the University of Arkansas at Fayetteville arranged for an internship with the State Medical Examiner's Office in the Arkansas State Crime Lab. The purpose of the internship is to give the student a better understanding of medico-legal investigations and a holistic view of forensic science. The student observes and participates in a wide range of medico-legal investigations. A detailed outline of this program is provided.

Topographic effects on measures of primate habitat-use in mountainous study sites in Japan and Africa. D. S. SPRAGUE, Nat. Inst. of Agro-Environmental Sciences, Tsukuba 305-8604, Japan, and A. MATSUMOTO-ODA, Dept. of Zoology, Graduate School of Science, Kyoto University, Kyoto 606-8502, Japan.

Primatologists working in mountainous habitats may need to account for the effects of topography on the data used to describe habitat-use in primates. Primatologists often record the location or travel routes of their study subjects on a flat map. These data then may be used to measure day-travel length or calculate a home-range area, often without regard for topography. However, mountainous topography increases values of distance and area compared to those obtained from a flat map. Topography may affect research results if the subject animals live in highly variable topography.

This study used a geographical information system to investigate how topography affected measures of travel distance and home range area with samples of travel route data on study groups in the Yakushima Japanese macaque study site (*Macaca fuscata*), and the Mahale Mountains chimpanzee study site (*Pan troglodytes*). Travel distance and home-range area were calculated first on a flat map. Then they were recalculated after draping travel routes and home-ranges on a digital elevation model. Distances and areas both increased. The increases differed by social group or season because samples represented travel routes passing through different parts of the terrain.

Sociosexual behavior of captive adult pygmy marmoset daughters before and after their mothers' deaths. L.B. SPURLOCK and M.A. NORCONK. School of Biomedical Sciences, Kent State University, Kent, OH 44242.

Among all species of callitrichid primates, familial influences (especially presence of the mother) are thought to play an important role in the reproductive failure of adult daughters. Scents, behavioral intimidation and presence/absence of an unrelated male may all be key factors. Little is known about the mechanisms of reproductive suppression in pygmy marmosets (*Cebuella pygmaea*), although Carlson et al. (1997) found that one of four adult daughters cycled while living in their natal families. This study explores behavioral interactions between five adult daughters (aged 14-31 months) and their family members 1) while their mothers were alive, and 2) immediately after their

mothers' deaths. Three daughters were housed with their mothers (2 different families) and two lived in a cage adjacent to their mother. Six categories of behavior were observed during focal animal sampling: aggression, piloerection, scent marking, grooming, sex, and priority at feeding.

Aggression, piloerection and grooming behaviors did not change significantly for any of the five daughters after their mothers' deaths. But three daughters showed dramatic increases in scent marking, receiving genital inspections, and/or gaining first priority at the feeding bowl. Two daughters showed no significant changes in any category of behavior; one was characterized by very low levels of scent marking and receiving genital inspections (under both conditions), and the other had high rates of aggression and moderate rates of scent marking throughout both phases.

Biweekly urine samples from all five daughters were collected throughout the study and will be assayed for progesterone to determine if or when each animal was cycling.

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The effects of substrate orientation on shoulder and hip angular excursions in *Aotus*. N.J. STEVENS, and S.G. LARSON, SUNY at Stony Brook, Stony Brook, N.Y. 11794.

The most common form of locomotion in primates is arboreal quadrupedalism. Recent work by Schnitt and others has documented kinematic differences between quadrupedalism on arboreal and terrestrial substrates. But an arboreal environment provides still more challenges to a quadrupedal organism. Branches become narrower and more compliant at their terminal ends, and consequently change in orientation under the weight of an animal. Yet it is often at the ends of these branches that insects, fruits, and other foods are found. Indeed, it has been suggested that the terminal branch environment has been instrumental in providing primates with many new opportunities for diversification.

In addition, numerous positional behavior studies have been conducted in the wild or in naturalistic settings which have documented the frequency with which animals use substrates of different orientations. Yet to date, there have been few systematic studies of kinematic variables on oblique arboreal substrates.

In this study, an adult *Aotus* monkey was filmed in the primate locomotion lab at SUNY-Stony Brook, walking both on a horizontal branch and on an oblique branch, oriented at 30° from the horizontal. Shoulder and hip angular excursions were digitized from videotapes using kinematic software, and horizontal, inclined, and declined steps were compared.

Results indicate that shoulder and hip angular excursions are larger on inclines, and smaller on declines than those seen on horizontal branches. The most pronounced differences are seen at toe-off, when both the shoulder and the hip are more retracted on inclines and less retracted on declines than those seen on horizontal supports. These results demonstrate that primates make kinematic accommodations to differences within their arboreal environment, and suggest that primates may adjust their limb alignment to correspond with changes in substrate reaction forces. Future work will examine the effects of

substrate orientation upon other kinematic and kinetic variables, in addition to how other variables such as substrate size and compliance contribute to primate arboreal quadrupedalism.

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Attention deficit hyperactivity disorder (ADHD): adaptive or maladaptive? J.C. STEVENSON¹, J.F. BAIRD², and D.C. WILLIAMS², Departments of Anthropology¹ and Biology², Western Washington University, Bellingham, WA 98225.

ADHD is the most common psychiatric condition, and many believe that the central disability for this disorder is impaired inhibition, which leads to reduced facility in social skills, self control, organization and time management. However, the behaviors identified by clinicians as problematic: inattention, hyperactivity, and impulsivity, have been incorporated into several evolutionary scenarios as a set of selectively adaptive cognitive skills for surviving the challenges of Pleistocene environments. We propose that the reduced facilities exhibited by ADHD individuals are maladaptive in most if not all contexts and include behaviors shared to varying degrees by all humans that were refined further and most recently, during the evolution of anatomically modern speech.

The proximate factors affecting the expression of ADHD behaviors seem to revolve around difficulties in self control but the ultimate factors leading to these behaviors reflect their critical role in human communication. Besides attention/inhibition deficits, ADHD individuals are developmentally slow in the process of internalizing speech and may be impaired in the creative uses of language. The cognitive systems and areas of the brain associated with attention and inhibition, as presently configured in modern humans, were most recently refined as a result of the coordination and timing needs of modern speech. There is much overlap and coordination between the areas of the brain for both language and attention/inhibition. These same regions are impaired in ADHD individuals including regions in the prefrontal cortex, basal ganglia and cerebellum. Assuming ADHD is a communication disorder also accounts for its high heritability, its association with aggression, and its differential expression by gender.

Sex determination from the humerus of South African blacks and whites. M. STEYN and M.Y. İŞCAN*, University of Pretoria, South Africa, *727 NW 7th Drive, Boca Raton, FL 33486.

It has been realised for a long time that distant and isolated population groups may need their own specific forensic osteological standards for determination of demographic characteristics such as sex and age.

The humerus is one of the most dimorphic bones of the human skeleton, yet little attention has been paid to its differences between the sexes. The purpose of this study is to analyse sexual dimorphism in the humeri of South African blacks and whites and develop population specific sex determination techniques using well documented modern skeletal collections.

Osteometric data was collected from 103 known white (55 male, 48 female) and 83 known black (40 male, 43 female) skeletons from the Raymond Dart and Pretoria skeletal collections. Humeral length, head diameter, minimum and maximum shaft diameters, circumference at deltoid tuberosity and epicondylar breadth were recorded and subjected to SPSS discriminant function analysis. For the whites, epicondylar breadth provided the best discrimination, followed by head diameter. For the blacks, head diameter was best, followed by humeral length. Discriminant function formulae were developed from these measurements.

Average accuracies were 89% for males, 96% for females in whites, and 95% for males and 91% for females in blacks. These figures remained unchanged after cross-validation. Humeral head diameter and epicondylar breadth were more dimorphic than other dimensions. These findings agree with those on Mongoloids and other blacks and whites. Furthermore, classification accuracy in the humerus was slightly greater than those obtained from the femur and tibia when used on South African whites.

In conclusion, this study supports earlier ones that South African males and females in both black and white populations are equally dimorphic, and it seems sex differences are better established when compared to other populations like Mongoloids including Chinese, Japanese and Thais.

Relationship of Body Composition Components to Bone Loss. W.A. STINI, Department of Anthropology, University of Arizona, Tucson AZ 85721.

The proportion of fat to lean tissue changes steadily with increasing age. In both males and females, body mass index increases up to the mid- or late fifties, then declines. However, even during the years when BMI is on the increase, the ratio of lean body mass to total body fat is decreasing. Recent studies of changes in total body potassium, a reliable predictor of cell mass, have shown that cell number decreases in the middle years of life even while BMI is increasing. The increase in absolute and relative total body fat is directly related to a decline in metabolic rate and total energy requirements. It has also been shown to be associated with increased risk of disability. The increase in disability arises from reduced mobility and agility, but may also reflect other changes such as bone density loss.

In order to identify changes in bone density associated with differences in fat and lean body mass, longitudinal bioelectric impedance and bone densitometry measurements were taken over a period of five years on a sample of 342 Arizona residents between the ages of 60 and 82 years. Although the increase in fat has been

emphasized by a number of investigators, it was found in this study that the strongest association with retention of bone density is with fat free tissue mass. Moreover, measures of trabecular bone loss, as seen in the ultradistal radius site reveal greater volatility than those of cortical bone loss, in this case at the distal one-third site on the radius. One unanticipated result of the study was that the rate of loss of trabecular bone in men exceeded that occurring in women, even though the initial bone densities of women were substantially lower. When body mass index values were examined, it was found that while the change in BMI and in total body fat were positively correlated in late middle age, BMI decreased while fat mass increased beyond age sixty.

Y chromosome diversity in *Pan troglodytes*.

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Several studies have demonstrated higher mitochondrial DNA diversity in *Pan troglodytes* compared to *Homo sapiens*. The investigation of other loci, however, has been limited. We are searching for variation in single copy regions of the non-recombining portion of the Y chromosome in order to investigate population history and substructure within *P. troglodytes* and to compare these findings with the human data.

Denaturing high performance liquid chromatography (DHPLC) is being used to search for polymorphisms in sequence tagged sites (STSs) located throughout the Y chromosome. DHPLC uses liquid chromatography to detect sequence mismatches in DNA heteroduplexes. The STSs were all identified on the human Y chromosome. To verify that these markers are Y specific in chimpanzees as well as humans, PCR was used to test each STS in a male and a female. To date, over 1 kb of sequence has been examined in more than sixty individuals. Several polymorphisms have been found including some that may be subspecies specific. Preliminary data indicate that the level of diversity on the Y chromosome in *P. troglodytes* is much greater than that found in humans ($\theta_H = 0.0005$, $\theta_C = 0.0013$) despite the inclusion of primarily *P. t. verus* in the sample.

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Ancestral pueblo women's bodies and lives. P.K. STONE, School of Natural Science, Hampshire College, Amherst, MA 01072.

This paper will focus on several sites from the Chaco Canyon region that

represent Ancestral Pueblo (Anasazi) peoples, to explore the role and position of women in the past by linking reproduction, workload and cultural practices. Empirical data on age at death and critical obstetric dimensions of the pelvis combined with ethnohistoric data on the birth process, birthspacing, and corn grinding will link the data in ways that are likely to contribute to more thorough interpretations with broader implications for anthropology. Though challenging, it is crucial that skeletal data be integrated with ethnohistoric studies and be channeled back into the discussion of gender, ideology and power.

Biogeographic implications of early hominid phylogeny. D.S. STRAIT and B.A. WOOD, Dept. of Anthropology, The George Washington University, 2110 G St. NW, Washington, DC 20052.

Despite the strong probability that early hominids migrated between East and southern Africa, few studies have examined the dispersal biogeography of early hominid species. These studies agree that either two or three dispersion events must have taken place, and that, in general, the early hominids followed the continental dispersion patterns of other large-bodied mammals. These patterns are believed to be driven by environmental factors; namely, it is believed that mammals should shift their ranges to match changes in the geographical distributions of vegetational zones.

Prior studies have examined the impact of ecology on biogeography, but the biogeographic implications of phylogeny have yet to be fully explored. Knowledge about phylogeny is crucial to the formulation of biogeographic hypotheses, because if a species in one region is descended from an ancestor in another region, then a dispersion event must have taken place. The biogeographic patterns implied by early hominid phylogenies were examined, and compared to the known dispersal patterns of Plio-Pleistocene mammals from East and southern Africa.

All recent published phylogenies require between four and seven hominid migration events between southern Africa, East Africa, and the Malawi Rift, a greater number of dispersals than suggested by previous studies. Moreover, the correspondence between hominid and other mammalian dispersal patterns depends critically on the ages of particular hominid specimens. If specimens attributable to *Homo habilis* and *Paranthropus robustus* in southern Africa are younger than 1.8 Myr, then hominid dispersals conform entirely to mammalian trends. If, however, either of these species appear in southern Africa before 1.8 Myr, then many phylogenies imply that at least one hominid species migrated in the direction opposite that of contemporaneous mammals. This suggests that those hominids may have possessed anatomical or behavioral adaptations that allowed them to depart from continental mammalian trends.

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Distinguishing facial morphology in sub-adult skeletal remains from closely related populations. U.STRAND VÍÐARSDÓTTIR, University of Durham, DH1 3HN, UK, P.O'HIGGINS, University College London, WC1E 6JJ, UK, C.B.STRINGER, The Natural History Museum, SW7 5BD, UK.

Although there are ways of reliably assessing major population affinities using the facial skeleton of adult modern humans, sub-adult facial skeletons are generally not considered sufficiently morphologically distinct to provide a good indication of population affiliation. Changes in form due to allometric growth during development have also made this task more difficult. Recently the advent of new analytical techniques to assess morphological variability has allowed us to study inter and intra population differences in facial form during post-natal growth, and to examine the possibility of developing models of population specific morphologies at all ages.

This study seeks to find a model of morphological separation between age-series of two closely related modern human groups, Aleutians and Alaskan Inupiaq Eskimo. The facial growth trajectories of the two groups are modelled using Principal Components Analysis of Procrustes registered three-dimensional landmark data from the facial skeleton. This method allows the removal of those shape differences which are solely due to allometric growth, and subsequently a comparison of the two groups, irrespective of the age or sex of the individuals within them.

The results show that after removing allometric shape change there is an almost complete separation between the facial morphology of the two groups, irrespective of the age and sex of the individuals. This leads us to conclude that all the individuals studied could be assigned to the correct population group on the basis of facial morphology alone. Subsequently, given the availability of the correct reference age series, there is a strong possibility of developing population specific identification standards for adult and sub-adult facial remains using this technique.

Regional variation in human mandibular morphology. C.B. STRINGER, Human Origins Group, Department of Palaeontology, The Natural History Museum, Cromwell Road, London SW7 5BD, M.C. DEAN, Evolutionary Anatomy Unit, Department of Anatomy and Developmental Biology, University College London, Gower Street, London, WC1E 6BT, and L.T. HUMPHREY, Human Origins Group, The Natural History Museum.

Important fossil mandibles that bear on the issue of modern human origins such as those from Klasies River Mouth, Tabun, Kebara, and Qafzeh differ considerably in their size and morphology. It is not clear to what extent this variation in size and morphology simply mirrors that present in modern human mandibles. In order to address

this issue, we analyse the variability in the shape and size of 299 mandibles from a geographically representative sample of modern human populations. In addition we explore whether there is any regional patterning underlying the morphological diversity of modern human mandibles.

In an analysis of 10 populations, 74.3% of mandibles were correctly classified using discriminant functions based on a series of 13 measured variables. A disproportionate number of the African mandibles which were incorrectly classified were wrongly attributed to other African populations, indicating that there is an African mandibular morphology that is able to accommodate geographically diverse African groups to the partial exclusion of non-African groups.

Principal components analysis demonstrates considerable overlap between the distributions of five regional groups. The Australian sample is closest to the average of all human populations in shape and size, and is nested within the variation of the African groups. A subrecent European population (Poundbury) emerged as more different from a recent European population (Spitalfields) than other more diverse modern populations were from each other, suggesting considerable morphological plasticity in the mandible through time. Overall the data suggest that modern human mandibles show less regional patterning than crania, although the number of variables available for analysis may be a factor here.

Comparative size at maturity reaction norms in Old and New World monkeys. D. SU, Department of Anthropology, New York University, New York, NY 10003; WC HARTWIG, Touro University College of Osteopathic Medicine, San Francisco, CA 94115

Models of evolutionary theory account for phenotypic plasticity of measurable traits as reaction norms to environmental and growth rate constraints. Much of the reaction norm literature is focused on prospective models of, for example, how large an animal will be at maturity under a given constraint. These reaction norm models are difficult to apply to primate populations because of the problems associated with collection of data in the wild and experimenting with animals in captivity. Under the assumption, however, that primate biological variation is subject to consistent reaction norm influences, interspecific comparisons of a life history factor such as size at maturity may reveal significant differences in underlying phenotypic potential. Under the null hypothesis that the breadth of reaction norms should vary between primate species under different constraints, similar relative ranges between species may indicate a kind of phenotypic immunity to the reaction norm principle.

To test the predictions of such a null hypothesis we collected size at maturity data for more than 50 species of Old and New World monkeys. The range of values for each species was divided by or

regressed against the species mean to control for the effects of overall size on the absolute intraspecific range of values.

Results indicate that size at maturity reaction norm ranges are closely correlated to the absolute body size of a given species. Such an interspecific pattern of consistent relative ranges of variation in size at maturity reaction norms regardless of external constraint suggests that forces other than those incorporated by the reaction norm principle are influencing how variable a particular species is for this biological parameter.

A possible case of MHC heterozygote advantage in a baboon hybrid zone. S. SUAREZ, T. WOOLLEY-BARKER, C.J. JOLLY, T.R. DISOTELL, Department of Anthropology & NYCEP, New York University, New York, NY 10003, J.E. PHILLIPS-CONROY, Department of Anthropology, Washington University, St. Louis, MO, 61310, T.K. NEWMAN, Department of Genetics, Southwest Foundation for Biomedical Res, San Antonio, TX 78284.

Several theories have been advanced to explain the maintenance and evolution of high polymorphism in major histocompatibility (MHC) genes. Some similar and related theories have also been proposed to explain the maintenance and evolution of hybrid zones. We collected preliminary data regarding the evolution and maintenance of both MHC polymorphism and hybrid zones. Multilocus genotypes (from 14 microsatellites, including one Y-linked marker; transferrin; and RFLP haplotypes from the 896 region of the mitochondrial genome) were collected from ~45 individuals each of phenotypically pure anubis (*Papio hamadryas anubis*) and hamadryas baboons (*P.h.hamadryas*) near a hybrid zone in the Awash National Park, Ethiopia. Locus Diagnosticity Values (LDVs) were calculated for three classes of loci: loci tightly linked, loosely linked, and completely unlinked to the MHC. Tightly linked loci showed lower diagnosticity values than loosely linked and unlinked loci combined. This effect was weakly significant, suggesting that some form of balancing selection is operating on the MHC, either to maintain ancient polymorphism (which we cannot rule out), or to favor the inclusion of foreign MHC alleles, permitting them to pass through the hybrid zone more quickly. In addition, diagnosticity was significantly higher in MHC-unlinked uniparentally inherited (the Y-linked microsatellite and the mtDNA RFLP haplotypes) than biparentally inherited loci. This may be an effect of smaller effective population sizes for these loci, with resulting increased rates of fixation.

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The scarlet fever epidemics of 1858-1868: A case of evolved pathogenic virulence? SWEDLUND, A.C., Dept. of Anthropology, UMass, Amherst, 01003 and A. DONTA, Dept. of Epidemiology, UMass, Amherst, 01003.

Between 1840 and 1880 there were several well documented epidemic outbreaks of scarlet fever in Europe and the United States, and by this time most physicians and those attending deaths were well attuned to the diagnosis of scarlet fever (or, scarletina), and could differentiate the disease from diphtheria by the presence of the characteristic rash, or "exanthem," that accompanied the sore throat, fever, inflammation of lymph nodes and abscessing of the throat and tonsils.

Recent research on *Streptococcus pyogenes* has shown that when contemporary outbreaks of scarlet fever occur often there is evidence for an increase in variant alleles of the gene (*speA*) of the type A strains. This gene encodes for the pyogenic exotoxin A. These variant alleles thus may be indicative of novel strains that have more virulent effects, and can be used to predict and monitor new outbreaks. Particularly severe epidemics of the past may well have resulted from new virulent strains of *Streptococcus pyogenes*. Competing hypotheses tend to focus on a number of socioeconomic factors, including nutritional status, and to those lacking resistance to the ubiquitous forms of *pyogenes* endemic in the population.

In the United States two severe scarlet fever epidemics occurred in 1858-59 and 1867-68. In four communities studied by the Connecticut Valley Historical Demography Project we have collected 227 cases of scarlet fever deaths surrounding the time of these epidemics. We conducted a microdemographic analysis of these cases using linked vital and census records. We are able to evaluate age, sex, socioeconomic status(ses), and geographic location of the cases, and to compare those cases occurring within the epidemic years with those occurring in non-epidemic years. Furthermore, we can plot the timing of the cases monthly. Our preliminary results suggest that a significant number of cases in the epidemic years occurred in households that could be considered of middle-to-high ses, and several of these are resident on successful farms where nutrition should have been more than adequate. We infer that the same epidemic that took Abraham Lincoln's and George Sheldon's sons was the result of a virulent new strain of *Streptococcus pyogenes*.

Dental size and morphology of precontact Marshall Islanders compared with other Pacific islanders. D.R. SWINDLER, University of Washington, Seattle, WA 98195, M. I. WEISLER, University of Otago, Dunedin, New Zealand, and S. L. COLLINS, State Historic Preservation Office, Honolulu, HI 96813.

The Marshall Island material is from five locations: the most southern Ebon Atoll; Kwajalein, Majuro, and Ujae Atoll in the middle of the archipelago; and the northern Utrik Atoll. All but the Majuro skeletal and dental material was collected by MIW during archaeological excavations between 1993-1997. Crown dimensions and morphological observations were made of the teeth. Shoveling was present on the upper I1-2 ranging from trace

to semi-shovel in 92% of I1's and 90% of I2's. This was a somewhat higher percentage than for Yap upper incisors, although the degree of shoveling was similar (Harris, et al., 1975). The hypocone of the upper molars was always present on M1-2 but was absent 17% on M3's. Carabelli's trait has a low incidence in Oceania and cusps with free apices are rare. In precontact Marshallese, the cusp was present on upper M1 39% which was about 10% higher than reported for Yap (Harris, et al., 1975). There was a medium-sized cusp with an independent apex in 11% of M1's. Of six upper dm2's 33% had Carabelli's cusps. The Y occlusal groove pattern on lower M1's is fairly high in the Pacific (Swindler, et al., 1998) and was present 90% of the time, the exact figure reported for M1 in Yap (Harris, et al., 1975). The presence of cusp six varies from 3% to 70% on M1 in the Pacific. The latter figure was for Yap which is somewhat higher than the 55% found in this study. M2 (21%) and M3(50%) were more variable. The metrical analysis revealed no appreciable differences in size from those of other Pacific groups except Australia, which were generally the largest of all Pacific peoples. The dental evidence suggests that precontact people living on the small atolls and coral islands in the eastern areas of Micronesia were in many ways dentally similar to the modern day Yapese who were found to be dentally more closely affiliated with peoples to the east (Polynesia) than to the south (Melanesians) (Harris, et al., 1975).

The Taphonomy of Bones Digested by Free-Ranging Chimpanzees in the Kibale Forest, Uganda. M. TAPPEN Anthropology, University of Minnesota, and R. WRANGHAM, Anthropology, Harvard University.

Chimpanzees are well-documented hunters of medium sized vertebrates such as monkeys. This is significant in the study of human evolution, especially in light of the widely held belief that the last common ancestor to chimps and humans was quite chimp-like. It suggests there was a pre-stone tool using hunting phase in human evolution, perhaps by an australopithecine or the last common ancestor. Taphonomically, this is very difficult to detect in the fossil record. If living, hunting, non-stone tool using hominoids leave a recognizable taphonomic signature on bones of their prey, we will be able to look for analogous signatures in fossil bones associated with fossil hominoids and hominids. We present a taphonomic study of bones that have passed through the digestive tracts of free-ranging chimpanzees from the Kibale Forest in Uganda.

The chimpanzee digested bone assemblage can be characterized as having a very low species diversity; low NISP (number of identifiable specimens) per scat; extremely broken up (very small size range); skeletal part frequencies similar in some ways to those resulting from carnivore digestion; and sometimes articulated specimens. Modifications to the bones include corrosion, tiny tooth scores and pits, cracking, and fraying of bone edges.

Together, these characteristics suggest that hominoid bone digestion is recognizable, despite some similarities with leopard, canid, and eagle modified bone.

The dental paradox? Dental lesions and systemic health. N. TAYLES and G.J. DIAS. Department of Anatomy and Structural Biology, School of Medical Sciences, University of Otago, Dunedin, New Zealand.

Multiple bony lesions caused by inflammatory responses to infection give the impression that a skeleton is that of an unhealthy individual. However, a good immune response may overcome or control infection. Depending on the nature and virulence of the infection, lesions could show that the spread of infection had been controlled. This is particularly so if the lesions have been remodelled, reflecting healing. The lesions may indicate that the individual survived a potentially fatal disease, at least for some time. Some types of lesions therefore could be interpreted as evidence of relatively good health. This is one aspect of the osteological paradox (Wood et al. 1992).

This principle can be applied with relative confidence to dental pathology for two reasons. Firstly lesions are common. Secondly, the specialised tissues and structures in the dentition, the constrained routes of infection, and the often localised inflammatory responses with clear-cut aetiologies mean that interpretation of lesions can be relatively easy. When the pulp of a tooth is exposed to infection through caries or attrition, a healthy individual with a good immune system may develop an adequate inflammatory response which will curtail the spread of any infection beyond the periapical region. The inflammation results in the formation of a periapical granuloma or cyst which appears as a cavity in dry bone. Even a periapical cavity which contained an abscess, indicating that the infection had overcome the immune defences to progress beyond the tooth itself, may nevertheless mean that the immune response controlled and localised the infection. In contrast, in the extreme case, an individual with a single carious lesion could have been immune-compromised with an acute dental infection which spread and manifested as acute osteomyelitis, septicaemia and rapid death. The inclusion of dental pathology in the interpretation of health status of skeletal populations through the use of caries, periapical cavity, and attrition prevalences ignores the function and relevance of the immune system. The implication of these dental pathologies for systemic health can only be interpreted by reviewing the complete picture in each individual and assessing the health status of the total from the sum of the individual assessments.

Masticatory form and diet in western lowland (*Gorilla gorilla gorilla*) and eastern lowland (*G.g. graueri*) gorillas. A.B. Taylor, Department of Physical Therapy, Samuel Merritt College, Oakland, CA 94609.

Evidence from behavioral and ecological studies suggests the western lowland gorilla (*G.g. gorilla*) is

considerably more frugivorous than the Virunga mountain gorilla (*G.g. beringei*). Previous comparative analyses by Taylor (1998) have revealed these subspecies differ predictably in jaw morphology as a function of dietary preference. Ecological data on the eastern lowland gorilla (*G.g. graueri*) suggest this species encounters less seasonal variation than *G.g. gorilla* and is intermediate in its dietary regime but the extent to which diet influences the masticatory complex in this subspecies has not yet been explored.

In this study, I compare maxillomandibular form between the western and eastern lowland subspecies of gorillas using ontogenetic data on 30 cranial and mandibular variables and mesiodistal and buccolingual dimensions of adult postcanine dentition on a total of 134 specimens (*G.g. gorilla* = 75, *G.g. graueri* = 59). ANCOVA was used to test for significant ($P < 0.05$) differences in mandibular scaling patterns (i.e., slopes and y-intercepts) between subspecies and principal components analysis (PCA) used to summarize patterns of subspecific variation in both jaw and dental morphology.

For most bivariate comparisons, patterns of mandibular scaling do not differ significantly between subspecies and PCAs on the cranial and mandibular variables confirm these results. For the PCA on dental dimensions, the second component clearly separates the two taxa with maxillary and mandibular premolar dimensions loading the strongest. The need to accommodate a larger premolar dentition may explain why *G.g. graueri* exhibits significantly greater dm1 and dm2 corpus heights vs. basicranial length. These results contrast previous findings of differences in jaw morphology between mountain and lowland subspecies of gorillas.

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Age, Locomotion, and Positional Behavior in Coquerel's Sifakas (*Propithecus verreauxi coquereli*). L.L. TAYLOR¹ and M.S. PASIN². ¹Department of Anthropology, University of Miami, Coral Gables, FL 33124-2005; ²Department of Anthropology, Northern Illinois University, DeKalb, IL 60115-2854

Little is known of the ways in which advanced age might be reflected in the behavior of prosimians. In this paper we report on patterns of behavior in two groups of sifakas, each of which contained one aged individual (25+ years of age). We used sampling by behavior techniques to gather data on the positional and locomotor repertoire of the lemurs. These data were used to test hypotheses concerning age-related differences in specific behaviors. A total of 4785 locomotion and 1967 positional scores were analyzed. Oldest animals leapt significantly less (23.7% vs. 36% of scores) but climbed (34.8%

vs. 25.2%) and walked (4.4% vs. 2.7%) more often than younger conspecifics. Aged animals were scored as sitting (65.2%) more often than younger animals (60.2%), and were scored in a vertical resting position most often (23.7% vs. 17.3%). Younger sifakas were scored in suspensory postures (11.9%) significantly more often than the aged individuals (5.6%). These results suggest that oldest animals were the more sedentary than other group members. When locomoting, they were most likely to be engaged in those behaviors that required the least exertion (e.g., walking instead of leaping). They rarely assumed a posture in which the entire body weight was suspended from only one or two limbs. These changes in behavior may compromise their ability to keep up with the group during daily travels and to forage normally, which could account, in part, for the lack of old animals in the wild.

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Food processing in different social groups of *Alouatta palliata*. M.F. TEAFORD, N. YAMASHITA, K. ALDRIDGE, Johns Hopkins University, Baltimore, MD 21205, K.E. GLANDER, Duke University Primate Center, Durham, NC 27705.

Teeth are a crucial link in the processing of foods by most mammals. Work by Kay and others has shown that differences in tooth shape can be correlated with differences in diet. However, all of that work has been based on analyses of unworn or slightly worn teeth. As tooth shape changes significantly with wear, one might ask if dental function also changes with wear. The purpose of this study was to see if older adult animals showed differences in food processing ability as compared with younger adult animals.

Adult mantled howling monkeys (*Alouatta palliata*) were captured as described by Glander et al. (1991) at Hda. La Pacifica near Cañas, Costa Rica. Dental impressions were taken from anesthetized animals, as were fecal samples and samples of stomach contents. Fecal samples and stomach contents were each washed through a progressive series of sieves with mesh diameters of 4mm, 1mm, 0.5 mm and 0.3 mm. Particles caught in each sieve were dried and weighed, with the weight caught in each sieve being treated as a percentage of the total weight of particles caught. Percentages for each sieve size were then compared between animals of different ages and between animals from different social groups.

Results indicate that, while older animals may have larger particle sizes in their fecal samples, and in their stomach contents, than do younger animals, animals from different social groups show far greater differences than those demonstrated between animals of different ages. It remains to be seen if these differences

are maintained through changes in food availability in different seasons.

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Evaluation of an enriched physical environment: space and structure utilization in *Pan troglodytes*. S. TECOT¹, M.L. JENSVOLD², AND R. FOUTS².

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Captive non-human animals face an existence unlike that found in their natural environments. There is general agreement that behavioral repertoires seen in the wild may be promoted in captive animals through an enriched environment. Prior research has shown that not only cage size but vertical spatial complexity are important factors concerning housing environments. More specifically, housing design should be analogous to that which is found in their natural environment to promote species-typical behaviors.

The purpose of this pilot study was a) to determine how five socially housed captive chimpanzees (*Pan troglodytes*) utilized vertical space, perimeters, and substrates, and b) whether a complex environment promoted the behavioral repertoire reported in other wild and socially housed captive groups of chimpanzees with respect to space and structure. Sixty hours of instantaneous scan-sampling data were recorded. Observations were made while the subjects occupied indoor and outdoor enclosures divided into rooms and zones respectively. Vertical location, substrate, structure, and zone were recorded for each chimpanzee every twenty seconds during thirty-minute sessions. The data show the chimpanzees used all of the rooms and zones, as well as all of the structures. While indoors they spent 59% of their time on a structure and 41% of their time on the ground. The tire (a first level structure) was used most frequently (52%), followed by the climbing structure (17%) and ledge (16%). While on any structure indoors they spent 45% of their time above 12 ft. Climbing structure level 3 (22 ft.) was used most often of the indoor vertical structures.

Outdoors the ledge was used most often (48.25%), followed by the cave (27.94%) and the cargo net (13.26%). Of the vertical structures, the chimpanzees used the ledge around the perimeter of the enclosure most often (65%), followed by the cargo net (18%). These data demonstrate a preference for diverse structures of varying heights. Access to vertical structures is important to these chimpanzees. These findings are in agreement with other wild and captive studies of space and structure utilization, and have implications regarding the relationship of captive enclosure design and the Animal Welfare Act to the care of captive non-human primates.

Thanks to the assistance of H. Hendrickson, C. Abshire, and M. Krause.

Infant diseases in Central Europe and the Near East during the Bronze Age. - W.-R. TEEGEN, Office of the State Archaeologist of Saxony-Anhalt, Halle (Germany), M. SCHULTZ, Center of Anatomy, University of Göttingen (Germany) and T.H. SCHMIDT-SCHULTZ, Center of Biochemistry, University of Göttingen (Germany).

Infant skeletons from Hainburg, Franzhausen-I. Gemeinlebam A, Gemeinlebam-F, Pottenbrunn-

Ratzersdorf, Spielberg-Pielamünd, Pitten, Stillfried (all Austria), Jelsove (Slovakia), Ikiztepe, Arslantepe, Nevali Cori, Troy (all Turkey) and Elephantine (Egypt) as well as some isolated remains or burials from the Ith Caves (Germany) and S. Giuliano di Toscanella and Grotta del Re Tiberio (both Italy) were examined by macroscopic, radiological, endoscopic, light and scanning-electron microscopic techniques.

In many of these populations, the frequency of the inflammatory diseases as well as malnutrition corresponds to the degree of mortality. Children of the lower social classes probably suffered more frequently from inflammatory diseases of the middle ear region and the paranasal sinuses than children of the upper social classes. Thus, in the Bronze Age the causes of diseases were already linked to the social-biological background. In particular, the following diseases were diagnosed with a relatively high frequency: Chronic vitamin-C-deficiency, chronic anemia, and in a very few populations (e.g. Hainburg, Jelsove, Ikiztepe) chronic vitamin-D-deficiency. These diseases were particularly frequent in very small babies. Furthermore, unspecific stress-markers such as transverse linear enamel hypoplasias and Harris's lines were found. It is well known for medieval and recent populations that malnutrition promotes infectious diseases. This has also now been demonstrated in Bronze Age populations. Additionally, some inflammatory diseases were also diagnosed with a high frequency (e.g. inflammatory and hemorrhagic processes of the meninges, skull trauma, and osteomyelitis). There was also evidence of some surgical intervention (e.g. trephination) in some skulls from Austria and Turkey.

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Evolution of haplotypes and complex diseases. A.R. TEMPLETON, Department of Biology, Washington University, St. Louis, MO 63130-4899

In complex diseases, the relationship of genotype to phenotype is not one-to-one, but rather can vary as a function of interactions with other genes and environments. Even when a good candidate locus exists for affecting the phenotypic variation of interest, only a small portion of the total phenotypic variation is expected to be explicable by genetic variation at the candidate locus because of the interactions that intervene between genotype and phenotype. Accordingly, in search for associations between genetic variation at candidate loci and complex disease phenotypes, it is critical to augment the signal over the noise as much as possible. From the genetic point of view, much noise is created by mutations that have little to no functional effect, which may often be the most commonly observed mutational types. The problem then arises as to how one identifies the one or handful of mutational variants that are associated with phenotypic variation in this noisy genetic background.

One method for increasing the genetic signal to noise ratio is to use evolutionary history. Mutations at a candidate gene occur in the context of prior mutations. At its time of creation, a new mutation will exist on a specific haplotype background containing some, but not all, of the mutational variants that had occurred earlier. If recombination is rare or is concentrated into hotspots, large segments of the candidate gene sequence will accumulate mutational change in a manner that reflects their evolutionary origin. Any mutation that causes a phenotypic change will therefore be imbedded in this evolutionary historical structure.

At first glance, this historical structure may seem to make

the job of finding genetic/phenotypic associations at the candidate locus even more difficult because it induces much linkage disequilibrium. Linkage disequilibrium in turn implies that various markers at the candidate locus are not statistically independent, undermining the validity of a site-by-site approach. However, by estimating the multi-site haplotypic states, and from those haplotypes estimating the evolutionary/recombinational history of the candidate region, those subsegments or subsets of the haplotypic variation that reflect evolutionary history can be identified. This evolutionary history in turn can be recast as a nested design in which nested branches (clades) of the evolutionary tree are used to identify in an efficient and statistically powerful fashion associations between molecular genetic variation and the complex disease phenotype. Hence, evolutionary history is used to focus in on the signal while eliminating much of the noise, in a manner similar to how evolutionary history of species is used in the comparative method of biology. Examples are given.

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Bioarchaeology at La Quemada: Current investigations on the mesoamerican mortuary program of the Malpaso Valley. D.T.O. Arizona State University, Tempe, Arizona 85287-2402

A bioarchaeological analysis of a large human skeletal deposit excavated at the West Mexican site of Los Pilarillos is reported. Los Pilarillos is a contemporary and subordinate village to La Quemada, a major ceremonial center located in the Malpaso Valley, Zacatecas, Mexico. La Quemada is interpreted as a pre-Toltec Epiclassic Mesoamerican site whose main occupation occurred between AD 600-750. Evidence of an extensive road system linking it to over 220 other sites in the valley and its settlement size place La Quemada at the center of the valley's socio-political organization. Osteological material previously found at the site suggests a complex mortuary system which included extensive cultural processing of human remains.

The skeletal deposit found at Los Pilarillos contains the remains of approximately 40-50 individuals; this study evaluates the fit of competing models of cultural taphonomy. The possibility of violence and associated ritual activity is assessed using information derived from an analysis of perimortem and taphonomic processes. These data are combined with observations taken *in situ* to generate information about each individual in the deposit. In view of the variability of mortuary treatment found in the valley, the burial could represent a range of possible cultural practices, including cannibalism, sacrifice, torture and slain captives of war. The individuals involved could be a part of a funerary chamber, revered community members, retainers for a high status burial, people who died in non-warfare catastrophes, soldiers who died in battle, or recovered bodies of soldiers held captive in a neighboring site.

Osteological and archaeological evidence allows for comparison with the expected patterns of each of the above possibilities for this deposit. The processes that led to it may yield vital information on the organization of the greater polity and of La Quemada's role as a Mesoamerican ceremonial center. When the stratigraphic context is well understood and more precise dates of differential treatment can be established, comparison of the deposit with others will permit assessment of changes in mortuary practices throughout the occupation of La Quemada. Such comparisons will be useful in determining when and under what conditions ritualized warfare was instituted, and has considerable potential for documenting the role of ancestor veneration as an integrative practice in the construction of social power.

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Fossil elephant diversity and environmental change in the African Neogene. N. E. TODD. Department of Biology, Manhattanville College, 2900 Purchase St., Purchase, N. Y. 10577

The evolution of the Proboscidea has been characterized by a series of "adaptive shifts," which have been used as the underlying explanation for the appearance and subsequent evolution of Proboscidean families, particularly in Africa. Changes in the masticatory apparatus resulting from increased dietary specialization have been linked with environmental and habitat change.

New analysis of diversity patterns in the Neogene African fossil record shows peaks of diversity in the middle Miocene and early Pliocene. However, there is no absolute correlation between these periods of diversity and significant environmental change. Lack of abiotic causality suggests that biotic interaction may be the principle force behind proboscidean evolution and diversification in Africa.

This interaction is best exemplified by the members of the Elephantidae. *Elephas*, adapted to more open, grassland environments, has traditionally been viewed as the more successful lineage dominating Plio-Pleistocene faunas. As a more "primitive" browser, *Loxodonta* was unable to compete successfully with *Elephas*, and only radiated after *Elephas* disappeared from Africa. The results from this analysis indicate that *Loxodonta* was as specious in the Plio-Pliocene as *Elephas*, and specimens of both are often found in the same fossil deposits. Species of these genera were not more or less successful than the other, but were constituents of different ecospace within a guild. This guild was an integral part of faunal assemblages associated with early hominids in Africa.

Mother and infant interactions and infant and nonmother interactions in mantled howling monkeys, *Alouatta palliata*, from the La Suerte Biological Field Station, Costa Rica and the Ometepe Biological Field Station, Nicaragua. B. N. TORGRIMSON, University of Wisconsin, Stevens Point, Stevens Point, WI 54481

Differences in early interactions between mothers and infants and nonmothers and infants influence the development of young primates. In particular, the type and quality of adult and infant interaction may affect infant survival (Clarke, 1990; Glander, 1980). The present study examined and compared infant interactions in free ranging mantled howling monkeys, *Alouatta palliata*, at the Ometepe Biological Field Station in Nicaragua and the La Suerte Biological Field Station in Costa Rica. This study occurred from June through August, 1998 during the wet season in a tropical wet rainforest in northeastern Costa Rica (La Suerte Biological Field Station) and during the wet season of a semideciduous tropical dry forest on the Island of Ometepe in Nicaragua (Ometepe Biological Field Station). Data were collected on mother/infant interaction, nonmother/infant interaction (evaluated

by quality of interaction and infant response), proximity to mother, infant activity, and infant independence. Data were collected every 2 minutes using an instantaneous focal animal point sampling technique. A total of 1,318 samples of quantitative data were recorded.

In concordance with other research (Clarke, 1990), results indicate that infant proximity to mother decreased substantially with increasing age, whereas, infant independence increased with age. Similarly, time spent feeding (independent of mother) and exploring increased with age. When they occurred, interactions between infant/nonmothers solicited primarily positive responses from the infant (78.6%). There were relatively few injurious interactions (5.7%), and all injurious interactions occurred between infant and adult nonmothers. I gratefully acknowledge the support of the Ometepe Biological Field Station and the La Suerte Biological Field Station.

Intentional artificial cranial deformation and its relation to sex in a Pre-Columbian population from San Pedro de Atacama, northern Chile. C. TORRES, Department of Anthropology, University of California, Santa Barbara, CA 93106.

Intentional artificial cranial deformation was practiced throughout the Andes in Pre-Columbian times. Ethnographic documents show that it was used to create class, lineage, ethnic or gender distinctions. Since cranial deformation requires a large parental investment and cannot result from achieved status, differences in frequency and/or type of deformation can be interpreted as varying degrees of interest in the social standing of a child. If the practice is equally frequent in men and women, then it may have been a symbol of group identity. If there are conspicuous differences between the sexes, cranial deformation would seem to be marking or reinforcing gender distinctions.

An archaeological collection of adult skeletons (n=92) from the site of Solcor 3 (400-900 AD), San Pedro de Atacama, Chile was examined for evidence of cranial deformation as a form of social differentiation based on sex. These skeletons represent a local Chilean population during a time of influence from the foreign state of Tiwanaku. This local group was weakly stratified, a fact that is reflected in burials and grave goods. This does not imply that there was not inherent stratification based on age or sex. Twelve cranial measurements were taken to quantify the deformation and to enable intrapopulation comparisons. Additionally, sex differences were analyzed with respect to type of cranial deformation. While over half of the sample shows evidence of some form of cranial deformation, this investigation indicates that there is not a statistically significant sex bias in the practice of cranial vault modification at Solcor 3. This can be seen as evidence that cranial deformation was used to distinguish social factors other than sex, such as lineage, community or class. Tabular forms of deformation are characteristic of this area and are the most frequent at this site. It should be noted, however, that no males have the Circular Erect form and twice as many females as males have Circular Oblique deformation. This could reflect the influence of the Tiwanaku culture where Circular forms of cranial deformation are prevalent. Many studies of cranial deformation focus on the alteration of metric and non-metric traits and neglect any potential for information about cultural processes. In the population from Solcor 3, analysis of artificial cranial vault

modification has given an insight into the workings of social differentiation.

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Y-Chromosome Phylogeny of the Macaques (Cercopithecidae: *Macaca*) • A.J. Tosi, J.C. Morales, & D.J. Melnick. Department of Anthropology and Center for Environmental Research and Conservation, Columbia University, New York, NY 10027

Reported are the results of one of the first analysis to use nuclear markers in elucidating primate phylogenetic relationships at the intrageneric level. Two closely-linked Y-chromosome markers, TSPY & SRY, were sequenced for a total of 3,059 bases. Forty-one macaques, representing 18 of the 19 recognized species (Fooden 1980), were sequenced for the full 3 kb, as was one individual from each of the following outgroup genera: *Papio*, *Theropithecus*, *Mandrillus*, *Allenopithecus*, *Cercopithecus*, *Trachypithecus*, and *Homo*. In contrast to recent mtDNA phylogenies (Hayasaka et. al 1996; Morales & Melnick 1997), Y-chromosome loci support 4 monophyletic species groups, including a *sinica* group containing *M. arctoides* -- a classification largely congruent with that of Delson (1980). These results are evidence that, at least for intrageneric analyses of groups where females are strongly philopatric, mitochondrial and nuclear phylogenies can yield different topologies. Further, they raise the question of what information is intended in a phylogenetic tree -- a direct, branching topology of species origins (as is likely to be drawn from mtDNA), or a depiction of more current species relationships, which may include subsequent episodes of introgression (as is more readily detected by the additional use of nuclear markers). This study was supported by a grant from the U.S. National Science Foundation (grant # 9707883).

Genetics of subcutaneous fat deposition before and after puberty. B. TOWNE, E.W. DEMERATH, R.M. SIERVOGEL. Division of Human Biology, Wright State University School of Medicine, Dayton, OH 45435.

The amount and distribution of body fat change during puberty, but little is known of the genetic architecture of

adipose tissue deposition during this stage of rapid development. We used a maximum likelihood statistical genetic method to estimate: 1) heritability (h^2) of triceps and subscapular skinfolds in prepubertal boys (10-12 years) and girls (8-10 years), and postpubertal boys (15-17 years) and girls (13-15 years), 2) genetic and environmental correlations (ρ_g and ρ_e) between triceps and subscapular skinfolds before and after puberty, and 3) ρ_g and ρ_e between pre- and postpubertal triceps skinfolds, and between pre- and postpubertal subscapular skinfolds, in 286 individuals from 93 kindreds enrolled in the Fels Longitudinal Study.

The h^2 estimates of pre- and postpubertal triceps skinfold were 0.99 ± 0.16 and 0.43 ± 0.18 , respectively, while those of pre- and postpubertal subscapular skinfold were 0.57 ± 0.20 and 0.33 ± 0.20 , respectively. The best bivariate model of prepubertal triceps and subscapular skinfolds constrained ρ_g and ρ_e between them to 1.00, while the best bivariate model of postpubertal triceps and subscapular skinfolds constrained ρ_g between them to 1.00 but estimated a ρ_e between them of 0.90 ± 0.05 . The best bivariate model of pre- and postpubertal triceps skinfold constrained ρ_g and ρ_e to 1.00, while the best model of pre- and postpubertal subscapular skinfold constrained ρ_g to 1.00 but estimated a ρ_e of 0.71 ± 0.11 .

These results indicate a common genetic background to triceps and subscapular skinfolds both before and after puberty, but an attenuation of genetic influences during puberty that is likely due to the emergence of both shared and site-specific environmental influences.

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Activity budget, diet, and patterns of resource utilization of the mantled howling monkey (*Alouatta palliata*) in Ometepe, Nicaragua. C.D. TRAVERS, Department of Anthropology, SUNY at Stony Brook, NY 11794.

Phenological variation in the availability and distribution of food resources in tropical forests has a considerable influence on primate behavior. In this study, I examine the activity budget, diet, and patterns of resource utilization in the mantled howling monkey (*Alouatta palliata*) during dry and wet season study periods. This research was conducted in a semi-deciduous dry tropical forest at Estacion Biologica de Ometepe, Nicaragua during December 1997-January 1998 (dry season) and July-August 1998 (wet season). Quantitative data were collected using instantaneous focal animal sampling at two-minute intervals. *Alouatta palliata* was observed for a total of 65.8 hours (23.8h dry season, 42h wet season).

The results indicate that the howling monkey activity budget was dominated by resting (79.3%). Activities such as feeding/foraging (12.5%) and traveling (6.9%)

accounted for less than 20% of all observations. Paired t -tests revealed no significant differences in the activity budget between the dry and wet season samples. There was evidence, however, of seasonal variation in the consumption of different plant parts. During the dry season the howling monkeys' diet was dominated by the use of flowers (45.8%) and flower buds (20.3%). Other food categories such as leaves (15.3%), fruit (8.5%), and petioles (6.8%) were eaten less frequently. In the wet season, however, leaves accounted for (76.6%) of feeding records. The remainder of the diet consisted primarily of fruit (18.9%). Plant families exploited during the dry season were, in many cases, also exploited in the wet season. Howling monkey dietary patterns at Ometepe appeared to be consistent with published data from other howling monkey populations studied in Panama, Mexico, and Costa Rica, suggesting the same dietary niche (Milton, 1980). Additional relationships between howling monkey foraging behavior and the distribution and exploitation of feeding trees are discussed.

Support for this project was provided by the Ometepe Biological Field Station.

The history of prehistory: an analysis of a skeletal sample from Cahokia.

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Ninety skeletons curated at the FMNH are believed to have been a part of Franz Boas' personal collection. Accession records indicate that the skeletal remains are from Cahokia. In this paper a model of demographic and pathological patterns associated with prehistoric urban environments is created. These results are compared to the FMNH sample.

The skeletal analysis of the FMNH material indicates that no juveniles are present, and that 12% (11/90) of the sample are between 17-25 years old. The majority of the individuals (22%, 20/90) are over the age of 50. Pathological conditions are common, with 89% (54/61) of the individuals with parietals displaying porotic hyperostosis, 60% (33/55) with a permanent canine displaying enamel hypoplasias, and 30% (20/66) of the sample with a permanent molar displaying caries. Periosteal reaction is found in 6.7% (6/90) of the population. Depression fractures of the cranium are found on 16% (10/61) of the population, and 61% (37/61) of the crania in the collection display deformation.

These data introduce similarities and differences between the FMNH sample and published analyses of other Mississippian populations. The results are discussed in light

of regional prehistoric spacial and temporal variation, subsistence strategies, and biases within 19th century archaeological practices.

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Orbital Convergence in Small-Bodied Arboreal, Nocturnal Mammals: Implications for Primate Origins.

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Cartmill (1972) showed that euprimates have high degrees of orbital convergence which he interpreted as evidence that the earliest primates were visually directed predators. This hypothesis was countered by Sussman (1991) who linked primate origins with the exploitation of angiosperms early in the Cenozoic. Interspecific patterns of orbital convergence have not been examined in many non-primate faunivores and nectivores but should be investigated in order to test the aforementioned hypotheses.

Models for the origin of primate orbit orientation were reevaluated in a broad comparative sample of 16 small-bodied arboreal, nocturnal species of chiropterans, dermopterans, marsupials, and primates. Six linear measurements were taken on each skull: skull length, palate length, basicranium length, cranial length, orbit diameter, and interorbital distance. Cranial capacity was calculated as endocranial volume and degree of orbital convergence was measured using a video-based image analysis system. Bivariate and multivariate techniques were used to investigate correlations between orbital convergence and each cranial dimension.

Results indicate that the highest correlation is with cranial capacity. Multiple regression analyses indicate that most of the variance in convergence values is explained by relative cranial capacity and relative interorbital distance, such that those taxa with the highest relative cranial capacities and narrowest interorbital distances have the highest convergence values. Nectar feeders have the lowest values of orbital convergence whereas frugivores and faunivores overlap considerably in their convergence values. These results suggest that, within this sample, high degrees of orbital convergence are not necessarily correlated with a specific foraging strategy but may instead be indirectly related to high relative cranial capacities and reduced interorbital distances associated with a variety of factors including body size and life history strategy.

A Biocultural Study of Health and Centralized Economic Authority during the Roman Period of Ancient Egypt.

TUCKER, T.L The Ohio State University.

Roman rule in Ancient Egypt is characterized as a period of great cultural and economic revival. Historic documents reveal a strong centralized government that prospered as measured in exports, revenues collected and territorial

expansion. However, Roman rule in Egypt has been described as unjust where "anarchy prevailed and religious persecution added to the misery of the people" (Fakrhy 1974:67). Indeed, analyses of Roman census data indicate that Egyptian females were subject to high mortality and life expectancy at birth was 22.5 years and for Egyptian males, life expectancy was 25 years (Bagnall and Frier 1994:57, 100). The objective of this research is to understand relationships between quality of life and centralized authority during the Roman period of Egypt.

This objective was tested by applying an interdisciplinary approach, drawing upon the fields of economics, nutrition, and anthropology to identify and understand relationships between economic status (as revealed by the archaeological record and historic records) and health (as scored by skeletal indicators of poor dietary intake, high disease loads, and trauma). Rock cut tombs from a Roman period cemetery were excavated from Baharia Oasis, Egypt; 350 km southwest of Cairo.

Preliminary analyses indicate a low incidence of trauma, high frequency of degenerative disease in both sexes, greater incidence of porotic hyperostosis in females and an older age at death for both males and females in comparison to Roman census data. Bioarchaeological comparisons between the Nile Valley/Delta and the Baharia Oasis indicate that the Oasis population had a lower incidence of skeletal stress and greater age at death.

The study of Roman Egypt is conventionally examined from the perspective of the rulers; the top down. Classical scholars are restricted to historical documentation. Bioarchaeological analyses allows the examination of direct evidence of life processes at all levels of Egyptian social status. This project integrates health within a comprehensive historical account of life in Roman Egypt, thereby improving our understanding of adaptation and fitness of the Egyptian population within the centralized economic authority of the Roman government.

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Infant diseases in pre-Columbian North American Southwest: The Anasazi population from Paa-ko. - R. TYSON, San Diego Museum of Man, San Diego (USA), M. SCHULTZ, Center of Anatomy, University of Göttingen (Germany) and T.H. SCHMIDT-SCHULTZ, Center of Biochemistry, University of Göttingen (Germany).

The importance of deficiency and infectious diseases as a selective impetus in human adaptation has been demonstrated very successfully during the last decades. Nevertheless, the dependence of the health situation on a possible change of environment in the pre-Columbian Southwest cannot be explained completely at this moment. Therefore, interdisciplinary studies on pre-Columbian populations of this geographic area are important for our understanding of prehistoric living conditions.

A total of 145 crania of subadults from the pre-Columbian settlement of Paa-ko, New Mexico, which is a typical Pueblo III site, were examined by macroscopic, partly also by radiological, endoscopic, light and scanning-electron microscopic techniques. As the skeletons are very well preserved detailed diagnoses could be carried out.

The mortality was, particularly at the infant age, relatively high: 2 individuals (1.4%) at the fetal age, 84 individuals (57.9%) of the age group *infans Ia* (newborn - 2 years), 30.5 individuals (21.0%) of the age group *infans Ib* (2 - 6

years), 19 individuals (13.1%) of the age group *infans II* (6 – 14 years), and 9.5 individuals (6.6%) of the age group *juvenis* (14 – 19) years.

The morbidity characterizes the Paa-ko subadults as a population in which nutrition was apparently based on maize (relatively high frequency of anemia). There are typical deficiency diseases such as scurvy (7/88 = 8.0%), rickets (1/88 = 1.1%), anemia (28/88 = 31.8%), and inflammatory diseases such as meningeal irritations (e.g. hemorrhagic-inflammatory meningitis, epidural hematoma) (52/88 = 59.1%), otitis media (2/74 = 2.7%), sinusitis maxillaris (14/50 = 28.0%), periodontitis (parodontitis) (23/63 = 36.5%), and dental caries (7/61 = 11.5%). Osteomyelitis was not diagnosed (0/88 = 0%). In summary, the morbidity and mortality of the subadults from Paa-ko are representative of a small population of agriculturists who based their economy mainly on maize.

The research was supported by the Deutsche Forschungsgemeinschaft (DFG).

To what extent might the short working day of Australian hunter-gatherers have been limited by heat stress? S.J. ULJASZEK, Institute of Biological Anthropology, University of Oxford, UK and W. MATTHEW, United States Army Research Institute of Environmental Medicine, Natick, Massachusetts).

Early reports of subsistence patterns of Australian aboriginal people suggested short working days, interpreted by some to reflect low needs for food and material acquisition typical of a state of 'primitive affluence' prevalent among hunter-gatherer societies. This view has been challenged on the basis of unrepresentativeness of populations and time periods of study that cannot be generalized to hunter-gatherer populations in their totality. Another possibility challenging the 'primitive affluence' argument is that the short day may be due to an avoidance of thermal stress. Ethical reasons preclude heat stress testing on living people at the climatic extremes postulated to limit work duration, and an alternative approach, involving the modelling of heat stress under varying climatic conditions, is used. The onset of heat stress in a model adult male aboriginal person working at a rate of 440 watts was predicted for four Australian climatic zones (tropical coastal, arid coastal, arid inland, and arid central). During days of high radiant heat load, the length of the working day is severely constrained by climatic factors in all but the central arid environment. This model suggests that the relatively short working day of Australian aboriginal people practicing hunter-gatherer lifestyles may have been constrained as much by heat stress as by other factors, at least during the hottest times of the year.

A preliminary study of molar occlusal relief in *Australopithecus africanus* and *Paranthropus robustus*. P.S. UNGAR, Anthropology, University of Arkansas, Fayetteville, AR 72701, M.F. TEAFORD, Cell Biology and Anatomy, Johns Hopkins University, Baltimore, MD 21205, and F.E. GRINE Anthropology, SUNY, Stony Brook NY 11794.

Analyses of molar shear potential have demonstrated consistent relationships between occlusal relief and diet for all major groups of extant primates. The study presented here extends this line of research to Plio-Pleistocene hominids.

High resolution replicas of all unworn lower second molars of *P. robustus* from Swartkrans ($n = 5$) and *A. africanus* from Makapansgat and Sterkfontein ($n = 4$) were examined. Kay's (1984) shearing quotients (SQs) were computed as a measure of occlusal relief. The mesiodistal diameter of the occlusal table and lengths of cusp ridges 1-8 were measured for each specimen. SQs were then calculated as residuals from a regression of summed ridge length and mesiodistal diameter for eight species of frugivorous extant hominoids.

Mean SQs for both hominid taxa are lower than averages for any living ape species. This contrasts with folivorous gorillas and siamang, which have values well above the extant frugivorous hominoid regression line. Further, the mean SQ for the Swartkrans sample is lower than that from Makapansgat and Sterkfontein. However, specimens identified as *A. africanus* show more variability in SQs than seen in *P. robustus*, with two specimens falling within the *P. robustus* range and two more closely approximating chimpanzee values.

These results suggest the following hypotheses: 1) these hominids may have had, as a whole, diets that included more hard, brittle foods than commonly eaten by living apes; 2) *P. robustus* may have eaten more hard foods than did *A. africanus*, assuming that the latter sample is attributable to a single species; and 3) specimens referred to *A. africanus* may represent two morphotypes, one with chimp-like occlusal relief, and the other with blunter teeth. Evaluation of these hypotheses must await testing using techniques that allow the inclusion of worn specimens.

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The limits and possibilities of micro CT scanning. C.J. VALERI, R.H. REEVES, C.B. RUFF, J.T. RICHTSMEIER, Department of Cell Biology and Anatomy, The Johns Hopkins School of Medicine, Baltimore, MD 21205.

Computed tomography (CT) scanners allow physicians and researchers to examine the internal structure of biological organisms in two or three dimensions in a non-destructive manner. The study of craniofacial dysmorphology relies heavily on data captured by CT

scanners. With the introduction of micro CT scanners, scientists are able to collect data from smaller organisms with higher resolution in a cost-efficient manner. These new micro CT scanners must undergo validation studies.

The crania of four normal mice were scanned using a Norland Systems PQCT micro-scanner housed at The Johns Hopkins University. The mice were of varying ages (1 day, 1 week, 2 weeks, 3 weeks) and were scanned at various voxel sizes and scan speeds to determine which scanner parameters would produce the highest quality CT slices in the least amount of time. These data were converted to binary format and transferred to a Silicon Graphics workstation. The CT scan data were reconstructed in 3D using REMEDI, and an attempt was made to locate 10 biological landmarks on the axial slices and on 3D re-constructions. Then, the heads from these mice specimens were prepared and 3D coordinates of the same landmarks were collected directly from the skulls using the 3Space digitizer.

Accuracy of the micro CT data was tested by comparing linear distances calculated between landmarks from the CT data and the digitizer data. The results of these comparisons allow us to conclude that increasing voxel size decreases scan time, but at the loss of resolution. In addition, the time required for scanning at high resolutions may be too great when scanning live animals. For example, it takes 1.5 hours to scan an adult mouse head using a 0.2 mm voxel size and a 1 mm slice thickness. This voxel size is not small enough to locate many of the traditional landmarks on the cranium. Micro CT scanners offer the biologist a new and useful tool. However this tool may not be appropriate for certain research problems.

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Distribution and evolution of feeding tool use in primates. C.P. VAN SCHAIK, R.O. DEANER, Department of Biological Anthropology and Anatomy, Duke University, Box 90383, Durham. NC 27705, USA.

We present a model to account for the inter- and intraspecific variation in manufacture and use of feeding tools in extant nonhuman primates. Any such model must explain why tool use is only found in a small subset of primate species, why many of these species use tools much more readily in captivity than in the wild, why routine reliance on feeding tools is only found in chimpanzees and orangutans, and why there is strong geographic variation in the incidence of feeding tool use and the composition of the tool kit within these latter two species.

Intraspecific variation in tool use in the wild is explained by the presence of suitable ecological niches (esp. extractive foraging) and the manipulative skills that go with them, and a measure of intelligence which enables rapid acquisition of complex skills (both through invention, and more importantly, observational learning).

Intraspecific variation in chimpanzees and orangutans is best explained by variation in the frequency of opportunities for transmission, and therefore by variation in association and especially social tolerance. We conclude that strong mutual tolerance was a key factor in the explosive increase in technology among hominids and probably intricately tied to a lifestyle involving food sharing and tool-based processing or acquisition of large, shareable, food packages.

Positional behavior of *Varecia variegata rubra* and *Lemur fulvus albifrons*. N. VASEY, Anthropology Dept., Pennsylvania State University, Univ. Park, PA 16802.

Positional behavior of sympatric *V. v. rubra* and *L. f. albifrons* was studied in the Andranobe Watershed, Masoala Peninsula, Madagascar. Data are examined under the hypothesis that each species has a repertoire influenced by the interaction between body size, diet, the spatio-temporal distribution of food resources, and energetic constraints of reproduction. Compared to *L. f. albifrons*, *V. v. rubra* is larger, more frugivorous, has a more spatio-temporally patchy diet (Vasey 1997), and a more costly reproductive pattern. To examine predictions of the above hypothesis, I collected posture and locomotion data over an annual cycle in relation to frequency of use, context of use, forest sites, support diameter and grade, and plant part eaten. Results indicate that *V. v. rubra* is less orthograde than *L. f. albifrons* during both feeding and travel using significantly less vertical leaping, climbing, and clinging and more suspension and horizontal leaping. *V. v. rubra* uses suspension mainly while feeding. Apart from suspensory locomotion, *L. f. albifrons* employs locomotor modes in more even frequencies than *V. v. rubra* during feeding and travel. Each species has a set of postures that are used rarely by the other species. During both feeding and travel, *L. f. albifrons* uses pronograde postures supplemented with orthograde postures, while *V. v. rubra* supplements pronograde postures with suspension. While feeding, both species use smaller supports for locomotion. While feeding, and especially while traveling, *L. f. albifrons* enters more forest sites and uses the ground and very small supports more often than *V. v. rubra*, while the latter remains mainly in tree crowns and uses all other support diameters more often. During both feeding and travel, both species use horizontal supports most often, yet *V. v. rubra* uses them more frequently while *L. f. albifrons* also uses vertical supports. To exploit a relatively small home range for a more diverse and less patchy set of resources, the smaller-bodied *L. f. albifrons* employs locomotor modes in more even frequencies and varied grades but remains on smaller supports, while *V. v. rubra* employs various tactics to conserve energy while monitoring a large home range for ripe fruit.